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Hybrid Indirect Evaporative Cooling Equipment

First Edition

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Eurovent, 80 Bd A. Reyers Ln, 1030 Brussels, Belgium
secretariat@eurovent.eu

Document history

This Eurovent Industry Recommendation / Code of Good Practice supersedes all of its previous editions, which automatically become obsolete with the publication of this document.

Modifications

This Eurovent publication was modified as against previous editions in the following manner:

Modifications as against	Key changes
1st edition	Current document

Preface

In a nutshell

The scope of this Eurovent Industry Recommendation / Code of Good Practice is to:

- **specify the requirements and test methods for IEC-hybrid units**
- **define how to calculate their Energy Efficiency Ratio and Total Cooling Capacity**
- **define a methodology suitable for Egypt's working conditions**

Authors

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Important remarks

Eurovent does not grant any certification based on this document. All certification-related issues are managed by the association's independent subunit Eurovent Certita Certification in Paris. For more information, visit www.eurovent-certification.com.

Contents

Background

The Hydrochlorofluorocarbons (HCFC) Phase out Management Plan (HPMP) Stage II was approved at the 79th meeting of the Executive Committee (EXCOM) of the Multilateral Fund for the Implementation of the Montreal Protocol (MLF) for the period from 2017 to 2025. At the 84th EXCOM meeting it was agreed to reduce HCFC consumption by 70 per cent of its baseline by 2025.

The UNIDO Project No. 140400 aims at providing technical assistance for the implementation of low GWP technology as well as examining the introduction of a not-in-kind technology, namely: indirect evaporative cooling (IEC).

The project also proposes to look into the introduction of IEC in commercial air conditioning applications.

Due to the absence of local testing standards or guidelines for IEC applications, this Eurovent Recommendation provides testing reference and quality review of the testing process.

Scope

The scope of this Eurovent Recommendation / Code of Good Practice is to:

- specify the requirements and test methods for IEC-hybrid units
- define how to calculate their Energy Efficiency Ratio and Total Cooling Capacity
- define a methodology suitable for Egypt's working conditions

Normative and legislation references

The following documents (non-exhaustive list), in whole or in part, are normatively referenced in this document and are necessary for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

- ANSI/ASHRAE Standard 133-2015 - Method of Testing Direct Evaporative Coolers, American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc., Atlanta.
- EN 14511-3: 2013. – Air-conditioner, Liquid Chiller packages & Heat Pumps with electrically driven compressor for space heating & cooling – Part 3 - Tolerance for reading temperature measurement.
- ANSI/ASHRAE Standard 143-2015 - Method of Test for Rating Indirect Evaporative Coolers, American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc., Atlanta.
- ASHRAE Standard 41.2-2018 - Standard Methods for Air Velocity and Airflow Measurement
- ISO 5801-2017 - Fans Performance testing using standardised airways
- ECP-24 EC:2021 - Technical certification rules of the Eurovent Certified Performance mark- Evaporative Cooling-

Terms and Definitions

Indirect Evaporative Cooler

An indirect evaporative cooler is generally equipped with integrated primary and secondary air passages and provided with both primary and secondary air-moving devices. Depending on product configuration a single air- moving device may be used for primary and secondary air. This device also includes the entire water distribution, collection, and might also include recirculation system with pump and piping. This type may have provisions for installation of other heat and mass transfer devices, such as a direct evaporative cooler and auxiliary heating and cooling coils. Primary air is always drawn from outside.

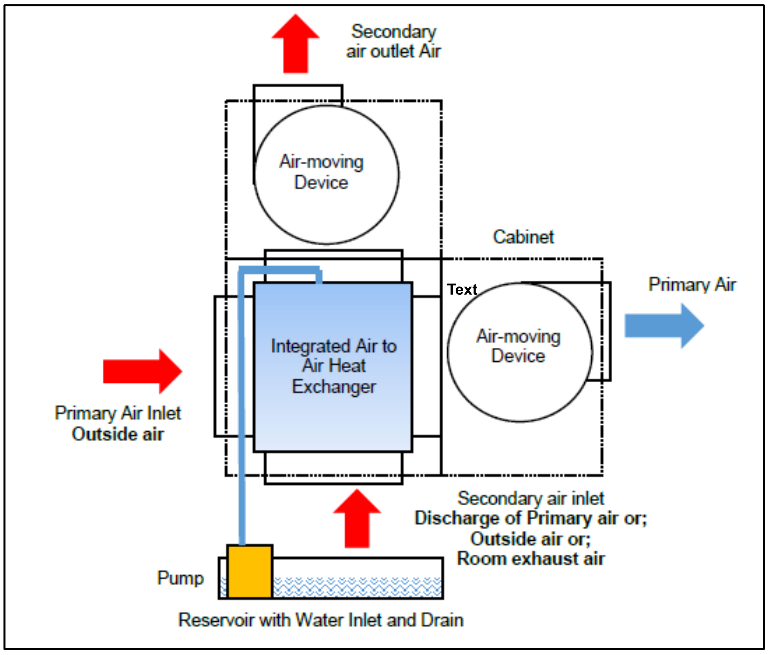

Figure 1: Schematic of an Indirect evaporative cooler

Hybrid Indirect evaporative cooling unit

Indirect Evaporative Unit can be equipped also with an additional direct expansion system or chilled water section in order to achieve the target supply air temperature even in the most critical external air conditions.

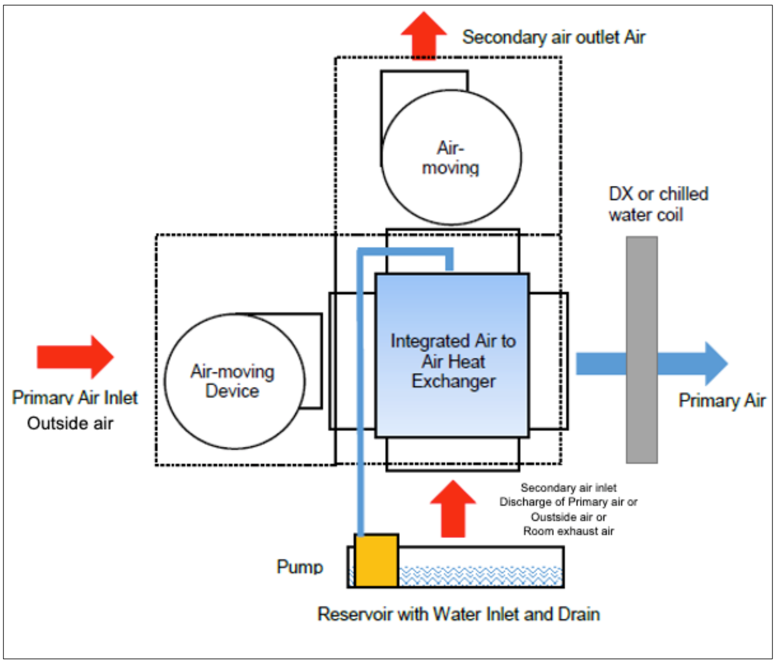

Figure 2: Schematic of a Hybrid Indirect evaporative cooler

Air Flow

The rate of air discharged by an evaporative cooler, expressed in litres per second (l/s) or metres cubed per second (m^3/s)

Primary air inlet

External air

Secondary air outlet

Hot air rejected to the atmosphere

Cooling Effectiveness

The cooling effectiveness (also called evaporation efficiency) of an Indirect Evaporative Cooling Unit

is calculated as follows:

$$e = \frac{(t_{d1} - t_{d2})}{(t_{d1} - t_{w3})} x 100\% \qquad [1]$$

Where:

- t_{d1}= Primary air inlet dry bulb temperature (as measured from test) [°C]
- t_{d2}= Primary air outlet dry bulb temperature (as measured from test) [°C]
- t_{w3}= Secondary air inlet wet bulb – Discharge of primary air; or Outside air; or Room exhaust air - (as measured from test) [°C]

Wet bulb Approach Effectiveness

Outside air dry bulb reduction divided by the outside air entering dry bulb temperature less the entering process wet bulb temperature.
The scope of the test shall be to measure the maximum external process air wet bulb temperature, for which the room supply air temperature can be guaranteed.

$$\varepsilon_{wet\ bulb\ approach\ effectiveness} = \frac{(t_{d1} - t_{d2})}{(t_{d1} - t_{w3})} \qquad [2]$$

Where:

- t_{d1}= Primary air inlet dry bulb temperature (as measured from test) [°C]
- t_{d2}= Primary air outlet dry bulb temperature (as measured from test) [°C]
- t_{w3}= Secondary air inlet wet bulb – Discharge of primary air; or Outside air; or Room exhaust air - (as measured from test) [°C]

Dry bulb Approach Effectiveness

Room air dry bulb reduction divided by the room air entering dry bulb temperature less the entering process dry bulb temperature.

The scope of the test shall be to measure the maximum external process air dry bulb, for which the room supply air temperature can be guaranteed.

$$\varepsilon_{dry\ bulb\ approach\ effectiveness} = \frac{(t_{d1} - t_{d2})}{(t_{d1} - t_{d3})} \qquad [3]$$

Where:

- t_{d1}= Primary air inlet dry bulb temperature (as measured from test) [°C]

- t_{d2}= Primary air outlet dry bulb temperature (as measured from test) [°C]
- t_{d3}= Secondary air inlet dry bulb – Discharge of primary air; or Outside air; or Room exhaust air - (as measured from test) [°C]

Total Cooling Capacity

The Total Cooling Capacity (kW) of the Indirect Evaporative Cooling Units is calculated (ANSI/ASHRAE Standard 143-2015 – Section 11) as follows:

$$q_{tot} = 1.21\, Q_p\, (t_{d1} - t_{d2}) \quad [4]$$

Where:

- t_{d1}= Primary air inlet dry bulb temperature (as measured from test) [°C]
- t_{d2}= Primary air outlet dry bulb temperature (as measured from test) [°C]
- Q_p= Primary air flow rate (as calculated under section 11.3.6 of the ANSI/ASHRAE Standard 143- 2015) [m^3/s]

Room Cooling Capacity

$$q_{room} = 1.21\, Q_p\, (t_{d1} - t_{de}) \quad [5]$$

Where:

- t_{d2}= Primary air outlet dry bulb temperature (as measured from test) [°C]
- t_{de}= Room exhaust air dry bulb temperature (fixed at 27.4°C for the tests) [°C]
- Q_p= Primary air flow rate [m^3/s]

EER – Energy Efficiency Ratio

The Energy Efficiency Ratio s the ratio of the total cooling capacity to the power input:

$$EER = \frac{q_{tot}}{W} \quad [6]$$

Where:

- q_{tot}= total cooling capacity
- W= Total Power input [kW] = $W_p+W_s+W_c+W_{DX}$
- W_p= Power of the fans for primary air
- W_s= Power of the fans for secondary air
- W_c= Power of the recirculating pump
- W_{DX}= Power of the direct expansion coils/system

Testing requirements

Operating conditions

The primary air inlet is the external air.
The following operating conditions and target room conditions must be used for the test of IEC with primary outside air, the following scenario must be tested:

- Primary air inlet dry bulb temperature: 38°C
- Primary air inlet wet bulb temperature: 21°C
- Room exhaust dry bulb temperature: 27.4°C

Depending on the source of the secondary air inlet the operating conditions must be as follows:

- Secondary air from primary air: as defined by the construction of the unit
- Secondary air from external air: 38°C dry bulb and 21°C wet bulb
- Secondary air from room exhaust air: 27.4°C dry bulb, 17.7°C wet bulb

Water consumption

Water consumption shall be tested as per the ASHRAE 133-2015 section 6.5.
The measurement shall be made for a period of at least 20 minutes on the unit supply water line. If there is an intermediate water tank, it will need to be refilled (topped up) at least 4 times to have a better accuracy on the efficiency.
Any water flushing cycles are excluded from the measurement.

Water inlet

The water inlet temperature shall not be less than 10°C.

Airflow

Airflow shall be tested as per the ASHRAE 143-2015 with the following condition on the fixed external static pressure: 80 Pa for an air flow less than 14,400 m^3/h.

Only the primary air shall be measured, it is not necessary to measure the secondary air. The primary air shall be measured at the outlet of the heat exchanger in order to take into account any losses through the heat exchanger.
Airflow can be measured as per the ASHRAE standard 41.2 with flow nozzles or Pitot tubes.

For the test the air flow of the secondary air shall be as declared by the manufacturer.

Measurement of the wet bulb temperature

Wet bulb temperature can be measured directly (as per the ASHRAE 143-2015, i.e. by using an air sampling device).

Measurement of the Dry bulb Temperature

Dry bulb temperature can be measured directly (as per the ASHRAE 143-2015, i.e. by using an air sampling device).

Tolerance on the Reading of the Temperature Sensors

The reading of the temperature sensor for the inlet condition shall be according to the EN 14511-3.

DX Integration

If a DX coil is integrated in the unit, it must be turned on during test.

Testing Procedure

- The primary air inlet is the external air, and the secondary air inlet is either:
  - The external air
  - A discharge of the primary air
  - The room exhaust air

Tests shall be performed as per the ANSI/ASHRAE 143-2015 Standard 'Method of Test for Rating Indirect Evaporative Coolers'.

- Wet bulb approach effectiveness calculation as per section III.9 and tests as per ANSI/ASHRAE Standard 143-2015.
- Dry bulb approach effectiveness calculation as per section III.10 and tests as per ANSI/ASHRAE Standard 143-2015
- Water consumption testing as per ANSI/ASHRAE Standard 133-2015
- Cooling Capacity calculation as per ANSI/ASHRAE Standard 143-2015, Section 11.5.
    - Total Cooling Capacity calculation, referenced to Outside air temperature
    - Room Cooling Capacity calculation - referenced to Room Exhaust air temperature
- Primary air inlet dry bulb: 38°C,Primary outside air wet bulb: 21°C.
- Room Exhaust Dry bulb: 27.4°C.

For Secondary air supplied from primary outlet air

Secondary air Dry bulb and Wet bulb conditions as defined by the construction of the Indirect EC under test.

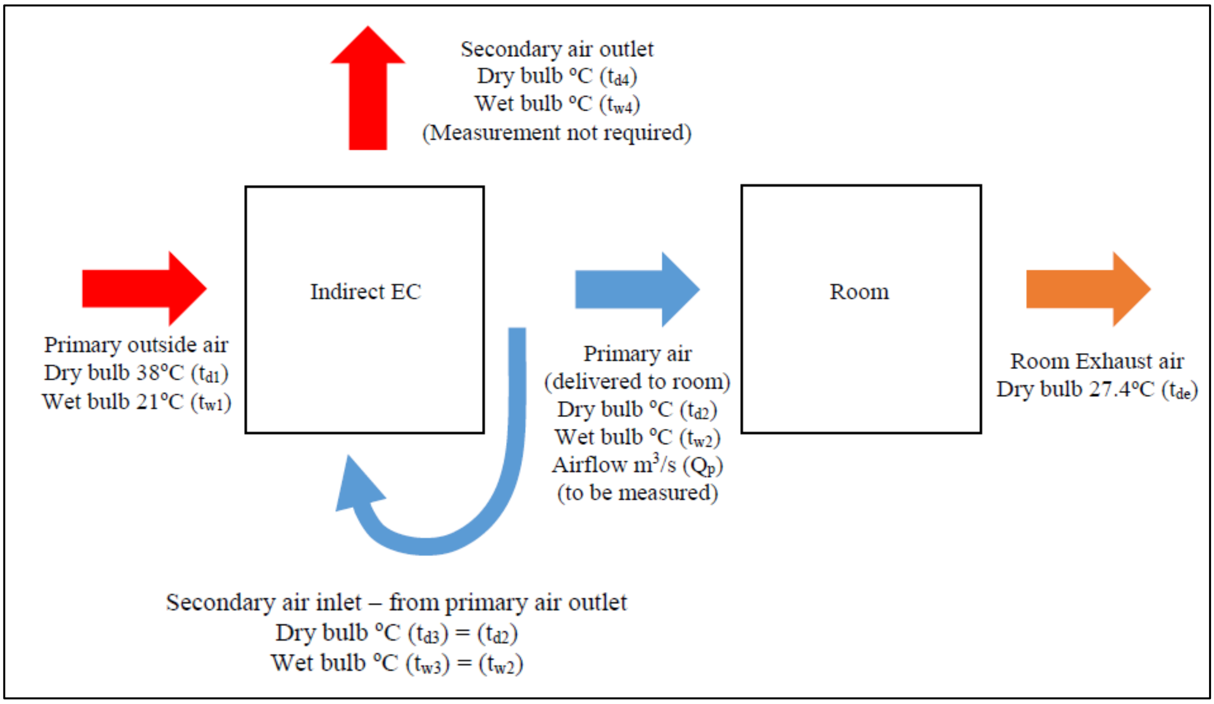

Figure 3: Testing Procedure of a Hybrid Indirect evaporative cooler with secondary air supplied from primary outlet air

For Secondary air supplied from outside air

Secondary air Dry bulb: 38°C, Secondary air Wet bulb: 21°C

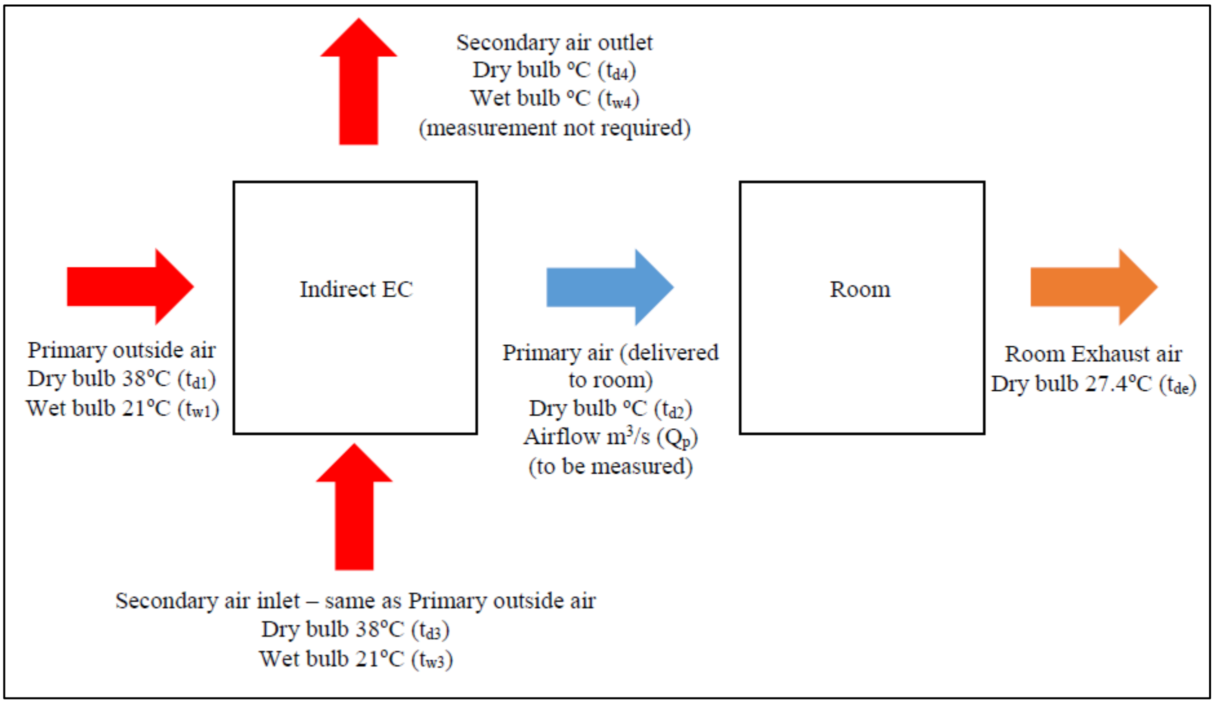

Figure 4: Testing Procedure of a Hybrid Indirect evaporative cooler with secondary air supplied from outside air

For Secondary air supplied from room exhaust

Secondary air Dry bulb: 27.4°C, Secondary air Wet bulb: 17.7°C

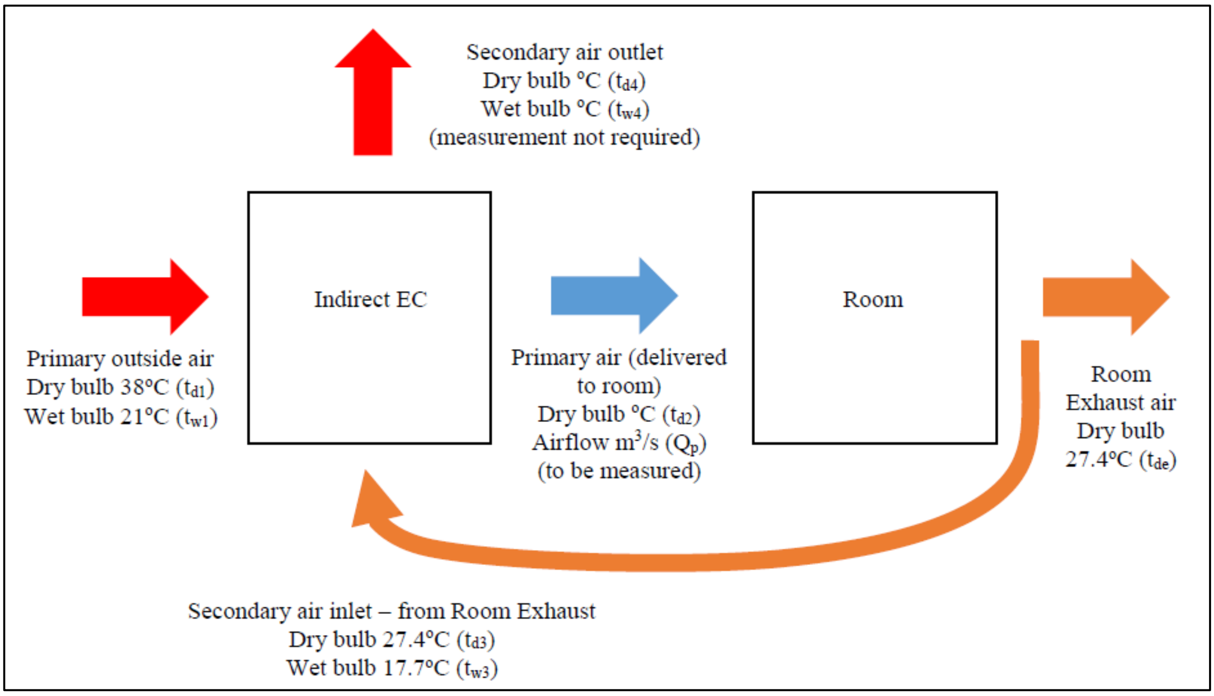

Figure 5: Testing Procedure of a Hybrid Indirect evaporative cooler with secondary air supplied from room exhaust

Instruments, measuring equipment and expanded measurement uncertainty

All measurements shall be carried out with instruments that have been calibrated to national standards and the measurement methods shall be in accordance with ISO 5801, except where specifically noted. The apparatus and instruments used in the test shall be listed. Names, model numbers, serial numbers, scale ranges and calibration information shall be recorded.

The instruments' expanded measurement uncertainty shall be:

- Temperature measurements shall be made to an expanded measurement uncertainty of ± 0,1K.
- Electrical energy consumption shall be measured to an expanded measurement uncertainty of ± 2 %.
- Time interval measurements shall be made to an expanded measurement uncertainty of ± 1 % or better.
- All temperature measurements shall be recorded at a maximum time interval of 10 min
- Differential pressure transmitters with scale 0-100 Pa shall have pressure measurements measured to an expanded uncertainty of ±3%
- The reading of the temperature sensor for the inlet condition shall be according to the EN 14511-3.

Egypt's working condition (climate zones)

Egypt has 8 different climatic zones out of which 7 climatic zones might be suitable for IEC applications due to lower humidity conditions across the summer season.

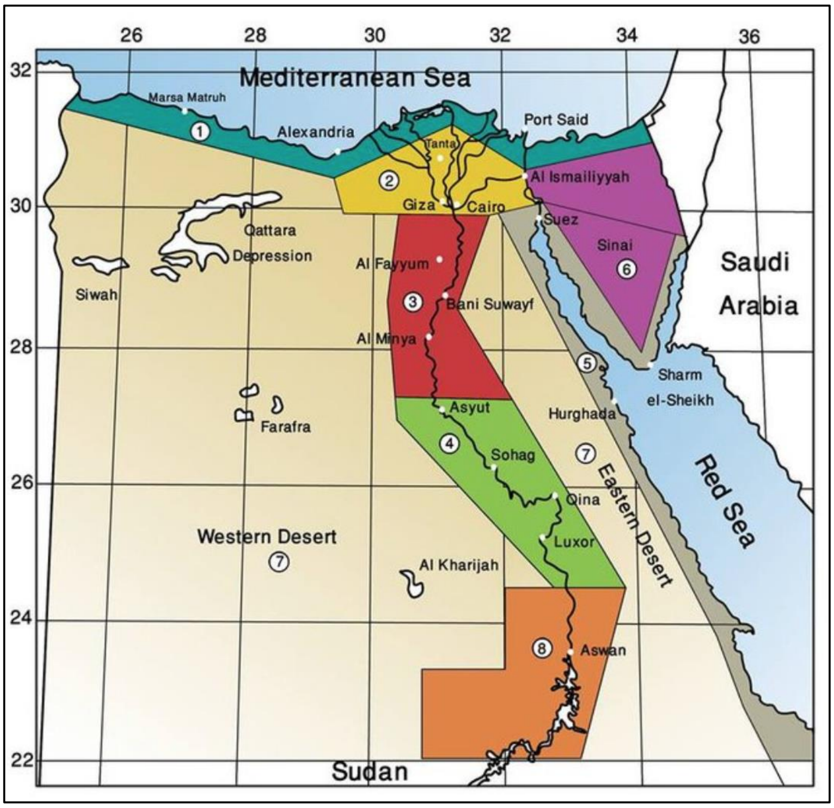

Figure 6: Egypt climate zones

#	Climate zone
1	North Coast Region
2	Delta and Cairo Region
3	North Upper Egypt Region
4	Southern Upper Egypt Region
5	Eastern Coast Region
6	High Heights Region
7	Desert Region
8	South of Egypt Region

Table 2: Egypt climate zones

Zone 1: North Coast Region (ALEXANDRIA/NOUZHA, EGYPT)

Annual Cooling, Dehumidification, and Enthalpy Design Conditions															
Hottest Month	Hottest Month DB Range	Cooling DB/MCWB						Evaporation WB/MCDB						MCWS/PCWD to 0.4% DB	
		0.4%		1%		2%		0.4%		1%		2%			
		DB	MCWB	DB	MCWB	DB	MCWB	WB	MCDB	WB	MCDB	WB	MCDB	MCWS	PCWD
8	**6.1**	**33.0**	**22.2**	**31.2**	**23.2**	**30.2**	**23.3**	**25.2**	**29.6**	**24.7**	**29.1**	**24.2**	**28.6**	**4.3**	**320**

Zone 2: Delta and Cairo Region (CAIRO, EGYPT)

Annual Cooling, Dehumidification, and Enthalpy Design Conditions															
Hottest Month	Hottest Month DB Range	Cooling DB/MCWB						Evaporation WB/MCDB						MCWS/PCWD to 0.4% DB	
		0.4%		1%		2%		0.4%		1%		2%			
		DB	MCWB	DB	MCWB	DB	MCWB	WB	MCDB	WB	MCDB	WB	MCDB	MCWS	PCWD
7	**11.5**	**38.1**	**21.1**	**36.7**	**21.3**	**35.2**	**21.5**	**24.9**	**31.8**	**24.2**	**31.0**	**23.7**	**30.3**	**5.4**	**350**

Zone 3: North Upper Egypt Region (MINYA, EGYPT)

Annual Cooling, Dehumidification, and Enthalpy Design Conditions															
Hottest Month	Hottest Month DB Range	Cooling DB/MCWB						Evaporation WB/MCDB						MCWS/PCWD to 0.4% DB	
		0.4%		1%		2%		0.4%		1%		2%			
		DB	MCWB	DB	MCWB	DB	MCWB	WB	MCDB	WB	MCDB	WB	MCDB	MCWS	PCWD
7	**13.6**	**40.0**	**22.2**	**38.5**	**22.2**	**37.1**	**22.0**	**24.4**	**35.4**	**23.7**	**34.6**	**23.2**	**34.0**	**3.5**	**20**

Zone 4: Southern Upper Egypt Region (LUXOR, EGYPT)

Annual Cooling, Dehumidification, and Enthalpy Design Conditions															
Hottest Month	Hottest Month DB Range	Cooling DB/MCWB						Evaporation WB/MCDB						MCWS/PCWD to 0.4% DB	
		0.4%		1%		2%		0.4%		1%		2%			
		DB	MCWB	DB	MCWB	DB	MCWB	WB	MCDB	WB	MCDB	WB	MCDB	MCWS	PCWD
7	**15.4**	**43.1**	**22.5**	**42.1**	**22.4**	**41.0**	**22.1**	**24.2**	**39.8**	**23.6**	**39.1**	**23.0**	**38.4**	**3.2**	**330**

Zone 5: Eastern Coast Region (HURGUADA, EGYPT)

Annual Cooling, Dehumidification, and Enthalpy Design Conditions															
Hottest Month	Hottest Month DB Range	Cooling DB/MCWB						Evaporation WB/MCDB						MCWS/PCWD to 0.4% DB	
		0.4%		1%		2%		0.4%		1%		2%			
		DB	MCWB	DB	MCWB	DB	MCWB	WB	MCDB	WB	MCDB	WB	MCDB	MCWS	PCWD
8	**8.6**	**38.6**	**22.0**	**37.5**	**21.9**	**36.6**	**21.9**	**24.9**	**33.1**	**24.2**	**33.1**	**23.7**	**33.0**	**6.6**	**10**

Zone 6: High Heights Region (ISMAILIA, EGYPT)

Annual Cooling, Dehumidification, and Enthalpy Design Conditions															
Hottest Month	Hottest Month DB Range	Cooling DB/MCWB						Evaporation WB/MCDB						MCWS/PCWD to 0.4% DB	
		0.4%		1%		2%		0.4%		1%		2%			
		DB	MCWB	DB	MCWB	DB	MCWB	WB	MCDB	WB	MCDB	WB	MCDB	MCWS	PCWD
8	**11.2**	**37.4**	**22.1**	**36.2**	**22.2**	**35.0**	**22.2**	**25.1**	**31.5**	**24.5**	**30.9**	**24.0**	**30.4**	**4.7**	**0**

Zone 7: Desert Region (SIWA, EGYPT)

Annual Cooling, Dehumidification, and Enthalpy Design Conditions															
Hottest Month	Hottest Month DB Range	Cooling DB/MCWB						Evaporation WB/MCDB						MCWS/PCWD to 0.4% DB	
		0.4%		1%		2%		0.4%		1%		2%			
		DB	MCWB	DB	MCWB	DB	MCWB	WB	MCDB	WB	MCDB	WB	MCDB	MCWS	PCWD
7	13.2	41.1	21.7	39.6	21.3	38.3	21.2	23.5	34.8	22.9	34.3	22.5	33.9	3.2	300

Zone 8: South of Egypt Region (ASSWAN, EGYPT)

Annual Cooling, Dehumidification, and Enthalpy Design Conditions															
Hottest Month	Hottest Month DB Range	Cooling DB/MCWB						Evaporation WB/MCDB						MCWS/PCWD to 0.4% DB	
		0.4%		1%		2%		0.4%		1%		2%			
		DB	MCWB	DB	MCWB	DB	MCWB	WB	MCDB	WB	MCDB	WB	MCDB	MCWS	PCWD
7	13.2	43.8	21.1	42.8	20.7	41.8	20.4	22.5	40.2	21.7	39.9	21.2	39.3	5.2	0

Comparison between laboratory and field conditions - Reference LAB conditions reproducing Egypt field conditions

The following matrix, based on the above-presented standard laboratory conditions, the ASHRAE data for the Climate Zones 2 and 5, and the climate data measured (Climate zones 2 and 5) within the UNIDO test campaign[1], provides for a proper comparison between laboratory test conditions and the Egypt field test conditions per climate zone. It also provides the possible laboratory testing conditions reproducing the average Egypt field conditions.

It is also to be noted that the below extrapolation matrix applies only in the case when the secondary air is supplied from outside air.

	Std. LAB conditions	CZ2 conditions (Ashrae)	CZ5 conditions (Ashrae)	CZ2 conditions (AVG measured)	CZ5 conditions (AVG measured)	Reference LAB conditions reproducing Egypt field conditions
t_{d1} [°C]	38,0	36,7	37,5	30,2	32,8	35,0
t_{w1} [°C]	21,0	21,3	21,9	21,4	22,3	21,6
t_{d3} [°C]	38,0	36,7	37,5	30,2	32,8	35,0
t_{w3} [°C]	21,0	21,3	21,9	21,4	22,3	21,6

Table 3: Assessment of the testing conditions

According to the above-done assessment and to the available measured data, it is finally possible to conclude that possibly laboratory conditions better fitting the Egypt conditions are:

t_{d1}= 35,0°C

t_{w1}= 21,6 °C

t_{d3}= 35,0 °C

t_{w3}= 21,6 °C

Test Report

For the Hybrid IEC under test the test report shall at least contain the following:

- Date of test
- Test identification number
- Latitude of the location where the test is done
- Longitude of the location where the test is done

[1] It is to be noted that measured climate data for CZ2 are limited compared to those for CZ5

- Altitude of the location where the test is done
- Indication of the Egypt climate zone
- Serial number
- Model dimensions
- Name of the manufacturer
- Trade name of the Hybrid IEC
- Reference to this Eurovent code of good practice (Eurovent 15/1 - 2023);
- Plot of the Primary air inlet dry bulb temperature
- Plot of the Primary air outlet dry bulb temperature
- Plot of the Secondary air inlet wet bulb
- Plot of the Secondary air inlet dry bulb
- Plot of the Primary air flow rate
- Plot of the Cooling Effectiveness
- Plot of the Total Power input
- Plot of the EER
- Plot of the room exhaust dry bulb temperature
- Plot of the total cooling Capacity
- Plot of the room cooling capacity
- Plot of the power of fans for primary air
- Plot of the power of fans for secondary air
- Plot of the power of the recirculating pump
- Plot of the power of direct expansion coils/system
- Plot of the water consumption

Marking Plate

Each Hybrid IEC shall have the following information marked in a permanent and legible manner in locations where it is readily accessible:

- The manufacturer's name or trademark or both
- Model and serial number of the cabinet
- Description of the units' internal fittings
- All information relating to the power supply (Frequency, Voltage, Current, Power) for which the unit is designed

About Eurovent

Eurovent is Europe's Industry Association for Indoor Climate (HVAC), Process Cooling, and Food Cold Chain Technologies. Its members from throughout Europe represent more than 1.000 organisations, the majority small and medium-sized manufacturers. Based on objective and verifiable data, these account for a combined annual turnover of more than 30bn EUR, employing around 150.000 people within the association's geographic area. This makes Eurovent one of the largest cross-regional industry committees of its kind. The organisation's activities are based on highly valued democratic decision-making principles, ensuring a level playing field for the entire industry independent from organisation sizes or membership fees.

Our Member Associations

Our Member Associations are major national sector associations from Europe that represent manufacturers in the area of Indoor Climate (HVAC), Process Cooling, Food Cold Chain, and Industrial Ventilation technologies.

The more than 1.000 manufacturers within our network (Eurovent 'Affiliated Manufacturers' and 'Corresponding Members') are represented in Eurovent activities in a democratic and transparent manner.

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